NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

SCHEDULING ARMY BASE REALIGNMENT AND CLOSURE

by

Mohamed M. AlRomaihi

June 2004

Thesis Advisor: Robert F. Dell
Second Reader: David H. Olwell

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2004	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE: Scheduling Army Base Realignment And Closure			**5. FUNDING NUMBERS**
6. AUTHOR (S) Mohamed M. AlRomaihi			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**
13. ABSTRACT (maximum 200 words) During four rounds of base realignment and closure (BRAC), the United States Army reduced its military infrastructure to meet its future national security and military requirements. After each round's closures and realignments were approved, all necessary actions (excluding some environmental cleanup) had to be scheduled over six years. The United State Army used an integer linear program, BRACAS (Base Realignment and Closure Action Schedule), to help guide the implementation of the 1995 round's actions. BRACAS schedules closure and realignment actions, and maximizes the net present value NPV of total cost savings while adhering to an annual budget and other constraints. This thesis updates BRACAS. Its main contribution is a more realistic inclusion of environmental cleanup costs. Using data based on the Army's 1995 round and letting BRACAS pick its yearly (1996-2001) budget, the refined BRACAS finds a 20-year NPV of $6,346 million. We examine how closures and the 20-year NPV are changed for several scenarios where we restrict yearly budgets and alter the inclusion of environmental cleanup costs.			
14. SUBJECT TERMS Base Realignment and Closure, BRAC, United States Army, Base Realignment and Closure Action Schedule, BRACAS, Net Present Value (NPV)			**15. NUMBER OF PAGES** 51
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

SCHEDULING ARMY BASE REALIGNMENT AND CLOSURE

Mohamed M. AlRomaihi
Major, Bahrain Defense Force (BDF)
B.S., University of Miami, 1988

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
June 2004

Author: Mohamed M. AlRomaihi

Approved by: Robert F. Dell
Thesis Advisor

David H. Olwell
Second Reader

James N. Eagle
Chairman, Department of Operations Research

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

During four rounds of base realignment and closure (BRAC), the United States Army reduced its military infrastructure to meet its future national security and military requirements. After each round's closures and realignments were approved, all necessary actions (excluding some environmental cleanup) had to be scheduled over six years. The United States Army used an integer linear program, BRACAS (Base Realignment and Closure Action Schedule), to help guide the implementation of the 1995 round's actions. BRACAS schedules closure and realignment actions, to maximize the net present value (NPV) of total cost savings while adhering to annual budgets and other constraints. This thesis updates BRACAS. Its main contribution is a more realistic inclusion of environmental cleanup costs. Using data based on the Army's 1995 round and letting BRACAS pick its yearly (1996-2001) budget, the refined BRACAS finds a 20-year NPV of $6,346 million. We examine how closures and the 20-year NPV are changed for several scenarios where we restrict yearly budgets and alter the inclusion of environmental cleanup costs.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

BAEC	Budget Allocation for Environmental Cleanup
BRAC	Base Realignment and Closure
BRACAS	Base Realignment and Closure Action Schedule
BRACO	United States Army Base Realignment and Closure Office
CIV-M	Civilian Moving
COBRA	Cost Of Base Realignment Action
CON-C	Construction Cost
CON-S	Construction Savings
CON-Y	Construction Years
DoD	United States Department of Defense
DTIC	Defense Technical Information Center
ENV-C	Environmental Cost
FRT-M	Freight Moving
GAMS	General Algebraic Modeling System
GAO	United State General Accounting Office
HAP	Homeowners Assistance Program
IRA	Interim Remedial Action
LTM	Long Term Monitoring
MIL-M	Military Moving
NPV	Net Present Value
OSAF	Optimal Stationing of Army Forces
OTHER-C	Other Cost
PERS-C	Personnel Cost
PROG-C	Program Cost
RA-C	Remedial Action Construction
RA-O	Remedial Action Operation
REC-S	Recurring Saving
RIF	Reduction In Force
RSE	Relocation Service Entitlement
SHUT-C	Shutdown Cost

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

I am very grateful and thankful first to my GOD and then to my government, the Bahrain Defense Force (BDF), for giving me this opportunity to achieve a Master's degree in Operation Research.

I would like to thank my parents, my wife, and my children for their support during my studies at this great school (NPS).

Finally, I would also like to thank my advisor, Professor Rob Dell, for his respect, support, directives and keeping me on track and focused on the task at hand. Also, I would like to thank my second reader, Professor Dave Olwell, for his direction in terms of technical writing.

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

During four rounds of base realignment and closure (BRAC), the United States Army reduced its military infrastructure to meet its future national security and military requirements. After each round's closures and realignments were approved, all necessary actions (excluding some environmental cleanup) had to be scheduled over six years. The United States Congress enacted two laws that provided for the four rounds of BRAC between 1988 and 1995. The four rounds of BRAC are referred to as BRAC 1988, BRAC 1991, BRAC 1993, and BRAC 1995, indicating the year each set of military installations was selected for realignment or closure. As a result of these two laws, the United States Army closed 112 major and minor installations and realigned another 27. Since 1995, the Department of Defense (DoD) has requested additional authorization to conduct another BRAC round. In 2002, such Congressional authorization provided for a 2005 round.

In the final BRAC 2005 selection criteria, the environmental impact, the impact of costs related to potential environmental restoration, waste management, and environmental compliance activities must be included. These environmental cleanup costs were not included in the overall cost and savings estimates in the previous four BRAC rounds, because they were considered a substantial liability regardless of the decision on installation closure or realignment. Forecasting or estimating these costs is important for budgeting and planning. The total amount spent by the United States Army on the closing and realignment of its 112 installations between 1988 and 2001 is $5.3 billion. Out of this total, the environmental cleanup cost is 43 percent ($2.3 billion).

The United State Army used an integer linear program, BRACAS (Base Realignment and Closure Action Schedule), to help guide the implementation of the 1995 round's actions. BRACAS schedules closure and realignment actions, and maximizes the net present value (NPV) of total cost savings while adhering to an annual budget and other constraints. BRACAS suggests timetables for BRAC actions that both satisfy yearly budget constraints and maximize NPV. Prior BRACAS implementations simply fixed the environmental cleanup costs each year, or equivalently, just reduced the available yearly budget. This thesis refines how environmental cleanup costs are modeled within BRACAS. It constrains yearly expenditures to be within a budget band (yearly lower and upper limits), adds a constraint to ensure a user-defined minimum total environmental funding over six years, adds a constraint that ensures minimum environmental funding before an installation is considered closed, and allows the environmental cleanup cost to be considered as part of the NPV calculation.

Using data based on the Army's 1995 round and letting BRACAS pick its yearly (1996-2001) budget, the refined BRACAS finds a 20-year NPV of $6,346 million. We examine how closures and the 20-year NPV are changed for several scenarios where we restrict yearly budgets and alter the inclusion of environmental cleanup costs.

I. INTRODUCTION

During four rounds of base realignment and closure (BRAC), the United States Army reduced its military infrastructure to meet its future national security and military requirements. After each round's closures and realignments were approved, all necessary actions (excluding some environmental cleanup) had to be scheduled over six years. The United State Army used an integer linear program, BRACAS (Base Realignment and Closure Action Schedule), to help guide the implementation of the 1995 round's actions [Dell 1998]. BRACAS schedules closure and realignment actions, and maximizes the net present value (NPV) of total cost savings while adhering to annual budgets and other constraints. This thesis updates BRACAS. Its main contribution is a more realistic inclusion of environmental cleanup costs.

A. BACKGROUND

The United States Congress enacted two laws that provided for the four rounds of BRAC between 1988 and 1995 [United States General Accounting Office (GAO) 1996]. The four rounds of BRAC are referred to as BRAC 1988, BRAC 1991, BRAC 1993, and BRAC 1995, indicating the year each set of military installations was selected for realignment or closure [Defense Technical Information Center (DTIC) 2004]. As a result of these two laws, the United State Army closed 112 major and minor installations and realigned another 27.

Including all U.S. service components, 497 major and minor installations have been selected for realignment or closure as a result of the four BRAC rounds [DTIC 2004]. Table 1 provides a summary of the major installations closed by BRAC round and service component.

	Number of Installations Closed				
BRAC ROUND	**ARMY**	**NAVY**	**AIR FORCE**	**DLA**	**TOTAL**
I (1988)	**11**	**3**	**5**	**--**	**19**
II (1991)	**5**	**9**	**13**	**--**	**27**
III (1993)	**3**	**19**	**7**	**1**	**30**
IV (1995)	**20**	**10**	**4**	**2**	**36**
TOTAL	**39**	**41**	**29**	**3**	**112**

Table 1. The Major Installations Closed by BRAC Round and Service Component. DLA is the Defense Logistics Agency (From DTIC [2004]).

Since 1995, the U.S. Department of Defense (DoD) has requested additional authorization to conduct another BRAC round. In 2002, such Congressional authorization provided for a 2005 round.

In the final BRAC 2005 selection criteria, the environmental impact, the impact of costs related to potential environmental restoration, waste management, and environmental compliance activities must be included [Meagher 2004]. These environmental cleanup costs were not included in the overall cost and savings estimates in the previous four BRAC rounds, because they were considered a substantial liability regardless of the decision on installation closure or realignment [GAO 1997]. Forecasting or estimating these costs is important for budgeting and planning. The total amount spent by the U.S. Army closing and realigning its 139 installations between 1988 and 2001 is $5.3 billion. Out of this total, the environmental cleanup cost is 43 percent ($2.3 billion) [Ardic 2001].

B. ENVIRONMENTAL CLEANUP

The main goals of environmental cleanup at BRAC installations are: (1) to reduce the risk to human health and the environment, (2) to ensure that all installations at the time of closing or realignment are environmentally suitable for transfer to other entities and, (3) to have the final remedies in place [U.S. Army BRACO 2004].

Many reasons exist for the high cost of environmental cleanup at a closed or realigned installation. These include: (1) the large number of contaminated sites and difficulties associated with the type of contaminations, (2) the lack of cost-effective environmental cleanup technology for certain contaminants (for example, unexploded ordnance), and (3) the intended property reuse [GAO 1996].

Figure 1 shows the phases associated with the DoD environmental cleanup: site investigation, remedial investigation, remedy decision, remedial action construction (RA-C), remedial action operation (RA-O), long term monitoring (LTM) and interim remedial actions (IRA). Each site starts the cleanup process with the site identification and site investigation phase. A site does not have to undergo all the phases while other sites may need indefinite LTM. Site closeout occurs when a site completes all the necessary phases [U.S. Army BRACO 2004].

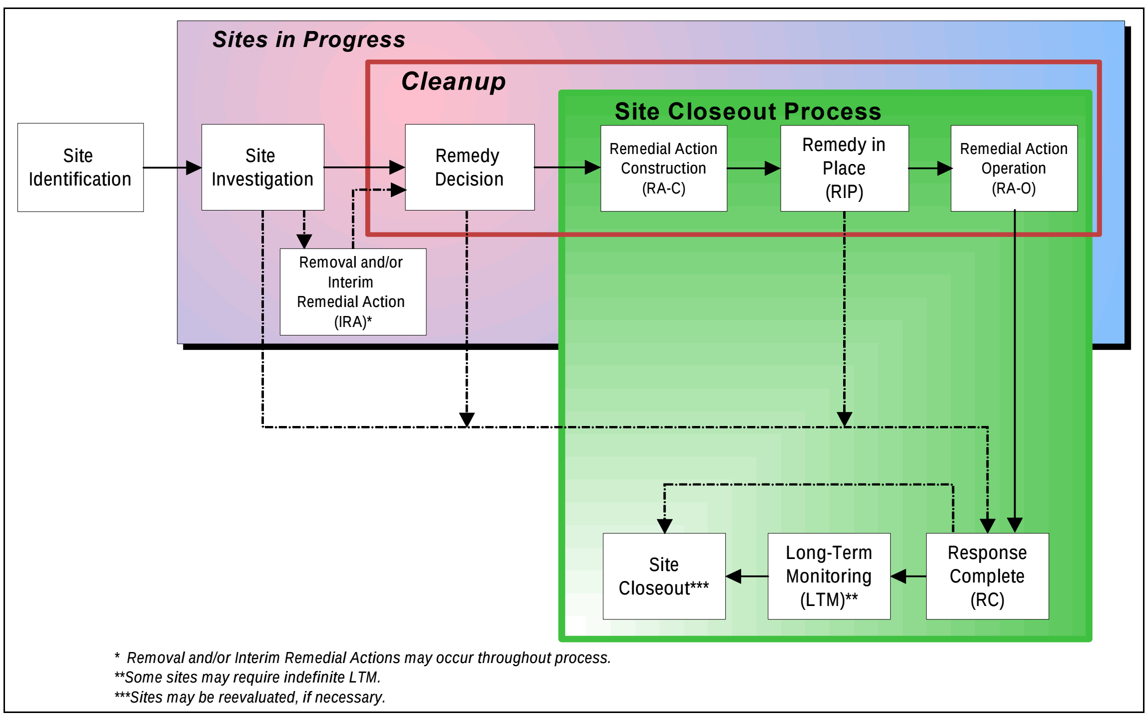

Figure 1. The Environmental Cleanup Phases of a DoD Site. Starting from site identification and site investigation, each site goes through some or all of these phases. After completing all the necessary phases, site closeout occurs (From U.S. Army BRACO [2004]).

C. PROBLEM DEFINITION

The main objective of BRAC is to improve military value. A one-time investment is sometimes required to close an installation before future cost savings can be accomplished. Congress created the Base Closure Account to provide the initial investment. This account provides funds for military construction, relocation expenses, environmental cleanup costs, and other one-time costs that result from base closure and realignment [U.S. Army BRACO 2004].

1. COBRA

To help standardize cost and savings estimates, all services and defense agencies used the Cost of Base Realignment Actions (COBRA) model for calculating BRAC costs, savings, NPV, and return on investment for installation closure and realignment actions [GAO 1997]. Because, DoD must cleanup all installations, the costs of environmental cleanup were not included in prior BRAC economic analyses and disregarded by COBRA [Dell 1998]. The COBRA model does not guarantee the best timetable for any closure or realignment scenario, but serves as a cost calculator [Dell 1998]. Changes to a timetable can influence the economic viability of a proposed action.

2. BRACAS

CORBA's limitations offer opportunities for improvement, and BRACAS is such an improvement. Free [1994] developed a prototype that evolved into BRACAS, Wong [1995] developed variations on the model, and Dell [1998] modified the model. This thesis updates BRACAS to more realistically include environmental cleanup costs.

D. THESIS OUTLINE

Chapter II discusses COBRA and some BRAC related optimization models. Chapter III provides an extensive description of BRACAS, its data, and its assumptions. Chapter IV uses data based on the U.S. Army's BRAC 1995 as a test case for the revised BRACAS. Chapter V presents conclusions.

II. COBRA AND BRAC OPTIMIZATION MODELS

The United States Army used COBRA and other models during its previous BRAC rounds. Below we provide a short description of some of these models.

A. COBRA

COBRA is designed to approximate the essential costs and savings associated with a proposed installation closure or realignment by using data readily accessible to military staff organizations [Dell 1998]. As described by Dell [1998], COBRA is a cost-benefit analysis model that allows an estimation of base closure and realignment alternatives using the NPV of costs from three categories:

- The cost of operations at the existing locations (old cost) includes
  - Personnel costs such as salaries and variable housing allowances.
  - Overhead costs such as the cost of base-operation support, real-property maintenance and administrative support.
- The cost of operations at the new locations (new cost) includes
  - Personnel costs such as salaries and variable housing allowances.
  - Overhead costs such as the cost of base-operation support, real-property maintenance and administrative support.
- The cost of the move to the new locations (BRAC cost) includes
  - Construction costs for new construction and renovations.
  - Personnel change of station costs (Personnel change of station is military jargon for moving personnel).
  - Transportation costs for freight, vehicles, and special equipment, and personnel costs such as severance pay and early retirement.

If the old cost is higher than the new cost, the difference is an estimate of the recurring yearly cost savings. The BRAC cost is the one-time cost required to recognize these cost savings [Dell 1998]. In all prior BRAC rounds, COBRA output data was used by each of the services and defense agencies to make a comparative judgment of different alternatives based on the NPV of the total savings less the one-time costs.

B. BAEC

Budget Allocation for Environmental Cleanup (BAEC) is a linear integer program used by the U.S. Army BRACO to help determine what site environmental cleanup to fund in what year while adhering to annual funding constraints [Oremis 2000]. Oremis [2000] reports on BAEC use in 2000 when each installation provided estimated environmental cleanup requirements for each site for fiscal years 2001-2007. These needs exceeded the U.S. Army's BRAC environmental cleanup budget for the similar period. BAEC permitted BRACO to analyze alternate yearly budgets and arrange site funding for the fiscal years concerned. Since 2000, BRACO has continued to use BAEC to help guide its funding decisions [Dell 2004].

C. OSAF

Optimal Stationing of Army Forces (OSAF) is an integer liner program adopted by the U.S. Army to support its 2005 BRAC round [Dell and Tarantino 2003]. OSAF prescribes an optimal U.S. Army stationing plan for a given force structure, set of installations, available implementation dollars, and stationing restrictions. OSAF usually minimizes the 20-year NPV of the stationing of a given force structure. OSAF has recently helped guide some Army unit stationing decisions. For example, OSAF helped to find the best location for rotary-wing training and a new home for the United States Army Southern Command [Dell and Tarantino 2003].

D. BRACAS

During the BRAC 1995 round, COBRA disregarded the environmental cleanup costs, and BRACAS did as well. Where it did account for these costs, BRACAS set the environmental cleanup cost to be fixed at the levels estimated by the individual installations [Dell 1998]. BRACAS suggests timetables for BRAC actions that satisfy yearly budget constraints and maximize the NPV [Dell 1998]. The need for an optimal schedule provided the impetus for Free [1994] to develop an optimization model to schedule BRAC actions within budget limits. For the model to be acceptable to the U.S. Army, the model inputs and the assumptions were consistent with COBRA. Free [1994] found that BRACAS achieved a 34 percent rise in cost savings over the manual schedule developed by the U.S. Army for their BRAC 1993 round.

BRACAS suggests timetables for BRAC actions that both satisfy yearly budget constraints and maximize NPV. The U.S. Army used BRACAS during BRAC 1995 to allocate funds within fiscal years and budget categories to obtain the highest potential cost savings. BRACAS assisted the U.S. Army in determining an initial plan to use to assign the $2 billion in BRAC 1995 costs over the six-year period mandated by Congress. Based in part on BRACAS results, the U.S. Army's senior leaders approved an increase of $100 million to its 1997 budget in order to produce an additional $233 million in cost savings over a six-year period [Dell 1998]. This thesis updates BRACAS to better model environmental cleanup costs.

THIS PAGE INTENTIONALLY LEFT BLANK

III. BRACAS

This chapter describes BRACAS, its data, assumptions, and formulation as an extension of the models found in Free [1994], Wong [1995], and Dell [1998]. BRACAS is an integer linear program. Its main objective is to maximize the NPV of total cost savings. It must ensure all costs necessary to achieve the installation closures and realignment are within annual budget constraints over a six-year period or it pays a penalty for violating the budget.

Prior BRACAS implementations simply fixed the environmental cleanup costs each year, or equivalently, just reduced the available yearly budget. This thesis refines how environmental cleanup costs are modeled. It constrains yearly expenditures to be within a budget band (yearly lower and upper limits), adds a constraint to ensure a user-defined minimum total environmental funding over six years, adds a constraint that ensures minimum environmental funding before an installation is considered closed, and allows the environmental cleanup cost to be considered as part of the NPV calculation. Actual environmental cleanup programs do not influence most calculated BRAC savings, and so this modeling should adequately account for the influence of environmental cleanup cost.

The thesis also modified BRACAS to maintain persistence [Brown, Dell, and Wood 1997]. The revised BRACAS includes one of the strongest forms of persistence where it is possible to schedule any closure action for completion by a given year.

A. DATA CONSISTENCY

The inputs for BRACAS can be consistent with the data from COBRA. Some COBRA data aggregations are possible as detailed below.

1. Data Generated From COBRA

Some input data are calculated for each losing installation and gaining installation. For consistency, this thesis adopts the same notations used by Free [1994], Wong [1995], and Dell [1998] wherever possible. Some of the descriptions from Free [1994], Wong [1995] and Dell [1998] are quoted below.

- CON-S is the procurement and construction cost avoided at a losing installation as a result of a BRAC action. All costs avoided are considered a cost savings realized in the first year of the transition period. CON-S includes the following one-time savings from COBRA: military construction cost avoided, family housing cost avoided, land sales cost savings, one-time moving cost savings, canceled moves cost savings, environmental mitigation cost savings, and one-time unique cost savings.
- REC-S is the net recurring cost saving for each lose-gain pair of installations when closure or realignment activity is completed. For each lose-gain pair of installations, the recurring cost savings for the losing installation (always positive) are based on the proportion of personnel and freight moving to the particular gaining installation. The recurring cost savings for the gaining installation (always negative) are based on the proportion of personnel and freight moving into it from the particular losing installation. REC-S for each lose-gain pair of installations is the sum of the two recurring cost savings.
- PROG-C is the overhead and program planning support costs at the losing installations on the support cost in COBRA. The total amount paid is initially distributed over four years where each year is discounted by 25 percent, subsequently adjusted based on the actual duration of BRAC transition of each installation.
- CIV-M is the cost to move all civilian personnel from a losing installation to a gaining installation. CIV-M includes the following costs from COBRA: moving cost, civilian moving cost, and civilian PCS (permanent change of station) cost.
- FRT-M is the cost to move freight from a losing installation to a gaining installation. FRT-M includes the following costs from COBRA: freight cost and one-time moving cost.
- MIL-M is the cost of moving all military personnel from a losing installation. In 1995, the average tour length for military personnel on a given installation is 26 months. Therefore, 12/26 or 46 percent of the cost to move military personnel in a given year can be considered due to natural rotation and not attributable to the BRAC action [Dell 1998].
- ENV-C is the one-time environmental cleanup cost at a losing installation because of a BRAC action.
- OTHER-C is the one-time cost at the losing or gaining installation. OTHER-C includes the following costs from COBRA: other cost, HAP (Homeowners Assistance Program)/RSE (Relocation Service Entitlement) costs, environmental mitigation cost, and one-time unique costs.
- SHUT-C is the mothball cost and shut down cost at a losing installation. SHUT-C includes the following costs from COBRA: mothball cost and shut down cost.

- PERS-C is the personal cost at a losing or gaining installation. It is the severance cost at a losing installation and the cost to hire new personnel at a gaining installation. PERS-C includes the following costs from COBRA: personnel cost, civilian RIF (Reduction in Force) cost, civilian early retirement cost, civilian new hires cost, eliminated military PCS (Permanent Change of Station) cost, and unemployment cost.
- CON-C is the construction cost at a gaining installation. CON-C includes the following costs from COBRA: military construction cost, family housing construction cost, information management account cost, and land purchases cost.
- CON-Y is the years required to complete construction at a gaining installation.

2. Data Manipulations in BRACAS

These data are broken down for each losing and gaining installation. Some of the descriptions from Free [1994], Wong [1995] and Dell [1998] are quoted below.

- UNIQG is the unique total one-time costs, and is the sum of OTHER-C, and SHUT-C costs at the gaining installations of each lose-gain pair of installations. The computation of UNIQG for each lose-gain pair of installations is based on the proportion of personnel and freight moving from the particular losing installation to the gaining installation.
- UNIQL is the unique one-time costs. It is SHUT-C costs at the losing installations.
- OVERHEAD is the program cost distributed over four years at the losing installation.

B. BRACAS ASSUMPTIONS

This thesis adopts the same assumptions used by Free [1994], Wong [1995], and Dell [1998] wherever possible. Some of the description from Free [1994], Wong [1995] and Dell [1998] are quoted below. The assumptions listed below are also consistent with the underlying assumptions of COBRA.

- The transition period for a post undergoing realignment or closure is no longer than six years. Therefore, all actions, which generate one-time costs and cost savings, must be scheduled to occur no later than six years.
- Any civilian RIF (reduction in force) necessitated by the closure of an installation occurs in the last year the installation is open.
- The discount rate that used in the NPV calculations is three percent and the inflation rate is zero percent.
- The fraction of personnel that can move onto a gaining installation without completing the construction at the installation is zero by default.

- An upper limit exists for the budget each year. The budget may be exceeded by BRACAS model when sufficient recurring cost savings are allowed by the violation. A budget penalty controls the degree to which the budget may be exceeded.
- The military construction paid for in year t is not completed until year $t+2$. This allows for planning and construction time.
- The first year of each construction project requires nine percent of the total construction cost. The remaining 91 percent is spread evenly over the rest of the project.
- BRACAS restricts moving a given portion of personnel and equipment to a receiving installation until the installation's new construction is completed.
- BRACAS recognizes some recurring savings even before all personnel complete their moves to receiving installation. Recurring cost savings are the net cost savings generated each year after the transition period is completed when activities are moved from one installation to the other. It is possible to realize portions of recurring cost savings during a transition period year based on what portion of the move is completed.
- BRACAS allocates COBRA early retirement costs for all civilians over the first three years of any action.
- BRACAS has some flexibility to schedule the costs of hiring new civilian and of moving civilians, military, and freight. In particular, it is necessary to pay all these costs before the action is complete.
- BRACAS has complete flexibility for scheduling COBRA costs for household assistance, environmental mitigation, one-time unique costs, mothball (maintaining an inactive installation), and shutdown.
- BRACAS uses the constant year dollars in all its costs to prevent any standardization or conversion, and neglects the evaluation of dollars from year to year. BRACAS assumes the dollar value of goods and services in term of the prices in the current constant dollar.
- Yearly environmental cleanup funding is restricted to a budget and PERLOW is the minimum percent of the total environmental cleanup cost at a losing installation in year t .
- Yearly environmental cleanup funding is restricted to a budget and PERHIGH is the maximum percent of the total environmental cleanup cost at a losing installation in year t .

C. ESSENTIAL ELEMENTS OF THE BRACAS MODEL

Free [1994], Wong [1995], and Dell [1998] use the same notation forms whenever possible. Some of the description from Free [1994], Wong [1995] and Dell [1998] are quoted below.

1. Indices

t, t' year of the closure process (t = 1,2,…,20)

l installation losing activity(s)

g installation gaining activity(s)

2. Index Sets

G_l set of installation gaining activity(s) from losing installation

L_g set of installations losing activity(s) to gaining installation

3. Data

a. Losing Installation (l) Cost and Saving Data in Constant Dollars

$CONSAV_l$ is all procurement and construction costs avoided as a direct result of realignment of the losing installation.

$ENVCOST_l$ is the environment cleanup cost attributable to the realignment of the losing installation that must be paid during first six years.

$ENVMIN_l$ is the minimum environment cleanup cost that must be paid before an installation can be considered closed.

$RECSAV_l$ is yearly savings after completing actions at the losing installation.

$RETIR_l$ is yearly civilian early retirement costs at the losing installation attributable to its realignment.

$SEVPAY_l$ is the cost for civilian reduction-in-force (RIF) attributable to the realignment losing installation.

$UNIQLCOST_l$ is the unique cost attributable to realignment of the losing installation.

b. Gaining Installation (g) Cost Data in Constant Dollars

$MILCON_{t'tg}$ is the cost of construction at the gaining installation in year t' (year t' dollars) when construction is finished in year t (i.e., $MILCON_{t',tg} = 0$ for all $t' \leq t$).

$NEWHIRE_g$ is the cost of all civilian new hires at the gaining installation.

$UNIQGCOST_g$ is the unique cost attributable to realignment of the gaining installation.

c. Transfer Cost from Losing to Gaining Installations (L, G) Data in Constant Dollars

$CIVPCS_{l\mathrm{g}}$ is the cost to move all civilians from the losing installation to the gaining installation.

$FREIGHT_{l\mathrm{g}}$ is the cost to ship all office and special equipment from the losing installation to the gaining installation.

$MILPCS_{l\mathrm{g}}$ is 54 percent of the cost to move all military personal from the losing installation to the gaining installation.

d. Additional Data

$CYEAR_g$ is the number of years required to complete construction at the gaining installation (i.e., $MILCON_{t'tg} = 0$ for all $t \geq t' + CYEAR_g$).

$DEVPEN_t$ is the penalty for exceeding the budget in year t.

DIS_t is the discount applied to a dollar in year t for the NPV.(DIS_t = $1/(1+d)^{t-0.5}$ where d is the COBRA discount rate.)

$FIXLOW_{lt}$ is one if installation l is forced to close in year t or it is zero otherwise.

$FIXHIGH_{lt}$ is zero if installation l cannot close in year t or one otherwise.

INF_t is the inflation to a dollar in year t (in COBRA, $INF_t = 1/(1+i)^{t-0.5}$ where i is the inflation rate. Standard DoD inflation rates for BRAC actions were used in BRACAS).

$IINF_t$ $(IINF_t = 1/INF_t)$.

NET_t $(NET_t = DIS_t * INF_t)$.

$OVERHEAHD_{lt}$ is the program cost distributed over four years at the losing installation.

$PERLOW_{lt}$ is the minimum percent of the total environmental cleanup cost to allocate at a losing installation l in year t.

$PERHIGH_{lt}$ is the maximum percent of the total environmental cleanup cost to allocate at a losing installation l in year t.

REQ_g is the fraction of personnel and freight that can move onto the gaining installation without completing construction at the gaining installation g.

$WEDGE_t$ is the total funds available for BRAC actions in year t (in year t dollars).

4. Variables

a. Binary Decision Variables

$build_{tg}$ is one if construction at the gaining installation g begins during year t (zero otherwise).

$done_{tl}$ is one if all actions at the losing installation l are complete during year t (zero otherwise).

b. Continuous Decision Variables

$civmove_{tlg}$ is the spending in year t (in year t dollars) for civilian movement from the losing installation l to the gaining installation g .

$civrif_{tl}$ is the spending in year t (in year t dollars) for civilian receiving RIF notices at the losing installation l .

dev_t is the spending in year t (in year t dollars) exceeding $WEDGE_t$.

$envir_{tl}$ is the spending in year t (in year t dollars) for environmental cleanup costs at the losing installation l .

$hire_{tg}$ is the spending in year t (in year t dollars) for hiring at the gaining installation g .

$milmove_{tlg}$ is the spending in year t (in year t dollars) for military movement from the losing installation to the gaining installation.

$ship_{tlg}$ is the spending in year t (in year t dollars) for shipping from the losing installation l to the gaining installation g .

$pper_{tl}$ is the fraction of realignment completed in year t for losing installation l .

$uniql_{tl}$ is the spending in year t (in year t dollars) for unique one-time costs at the losing installation l .

$uniqg_{tg}$ is the spending in year t (in year t dollars) for unique one-time costs at the gaining installation g .

5. Formulations

a. Objective Function (Maximizing the Saving)

$$\sum_{t=7}^{20}\sum_{l} RECSAV_l * NET_t - \sum_{t=1}^{3}\sum_{l} RETIR_l * DIS_t + \sum_{l} CONSAV_l * NET_1$$
$$+\sum_{t'=2}^{6}\sum_{t=2}^{t'}\sum_{l}(\frac{1}{4}RECSAV_l)*(NET_t)*(1*done_{t-1,l}+3*pper_{t-1,l})$$
$$-\sum_{t=1}^{6}\sum_{l} DIS_t*(uniql_{tl}+civrif_{tl}+envir_{tl})-\sum_{t=1}^{6}\sum_{g} DIS_t*(hire_{tg}+uniqg_{tg})$$
$$-\sum_{t=1}^{6}\sum_{t'=1}^{t}\sum_{g} DIS_t*(MILCON_{t'tg}*build_{t'g})-\sum_{t=1}^{6}\sum_{l}\sum_{g\in Gl} DIS_t*(ship_{tlg}+civmove_{tlg}+milmove_{tlg})$$
$$-\sum_{t=1}^{6}(DEVPEN_t*dev_t*DIS_t)-\sum_{t=1}^{4}(OVERHEAD_{tl}*done_{6,l}*DIS_t)$$

b. Subject to

$$\sum_{l(if\ t\le 3)}^{3} RETIR_l*INF_t+\sum_{l}(uniql_{tl}+civrif_{tl}+envir_{tl})+\sum_{g}(hire_{tg}+uniqg_{tg})$$
$$+\sum_{t'=1}^{t}\sum_{g}(MILCON_{t'tg}*build_{t'g}*INF_t)+\sum_{l}^{g}\sum_{g\in Gl}(ship_{tlg}+civmove_{tlg}+milmove_{tlg})$$

$$+\sum_{l}(OVERHEAD_{tl}*INF_t)\le WEDGE_t+dev_t \quad \forall\, t\le 6, \tag{1}$$

$$\frac{\sum_{t=1}^{t'}\sum_{g\in Gl}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{\sum_{g\in Gl}(CIVPCS_{lg}+MILPCS_{lg})}\ge\sum_{t=1}^{t'} pper_{tl} \quad \forall t'\le 6,\ l, \tag{2a}$$

$$\sum_{t=1}^{6} pper_{tl}\le 1 \quad \forall l, \tag{2b}$$

$$\frac{\sum_{t=1}^{t'}\sum_{l\in Lg}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{\sum_{l\in Lg}(CIVPCS_{lg}+MILPCS_{lg})}\le\frac{\sum_{t=1}^{t'}(IINF_t*hire_{tg})}{NEWHIRE_g} \quad \forall\, t'\le 6,\ g, \tag{3a}$$

$$\frac{\sum_{t=1}^{t'}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{(CIVPCS_{lg}+MILPCS_{lg})} \le \frac{\sum_{t=1}^{t'}(IINF_t*ship_{tg})}{FREIGHT_{lg}} \quad \forall\, t' \le 6,\ l,\ g \in G_l, \tag{3b}$$

$$\frac{\sum_{t=1}^{t'}\sum_{l\in Lg}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{\sum_{l\in Lg}(CIVPCS_{lg}+MILPCS_{lg})} \le \frac{\sum_{t=1}^{t'}(IINF_t*uniqg_{tg})}{UNIQGCOST_g} \quad \forall\, t' \le 6,\ g, \tag{3c}$$

$$\frac{\sum_{t=1}^{t'}\sum_{l\in Lg}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{\sum_{l\in Lg}(CIVPCS_{lg}+MILPCS_{lg})} \le REQ_g+(1-REQ_g)*\sum_{t=1}^{t'-CYEAR_g} built_{tg} \quad \forall\, t' \le 6,\ g, \tag{3d}$$

$$\frac{\sum_{t=1}^{t'}(IINF_t*uniql_{tl})}{UNIQLCOST_l} \ge \sum_{t=1}^{t'} done_{tl} \qquad \forall\, t' \le 6,\ l, \tag{4a}$$

$$\frac{\sum_{t=1}^{t'}(IINF_t*envir_{tl})}{ENVCOST_l} \ge \sum_{t=1}^{t'} done_{tl} \qquad \forall\, t' \le 6,\ l, \tag{4b}$$

$$\frac{\sum_{t=1}^{t'}\sum_{g\in Gl}(IINF_t*(civmove_{tlg}+milmove_{tlg}))}{\sum_{g\in Gl}(CIVPCS_{lg}+MILPCS_{lg})} \ge \sum_{t=1}^{t'} done_{tl} \quad \forall\, t' \le 6,\ l, \tag{4c}$$

$$\sum_{t=1}^{t'-CYEAR_g} built_{tg} \ge \sum_{t=1}^{t'} done_{tl} \qquad \forall t'\le 6, l, g\in G_l, \tag{4d}$$

$$PERLOW_{tl}*ENVCOST_l \le envir_{tl} \le PERHIGH_{tl}*ENVCOST_l \quad \forall\, t' \le 6,\ l, \tag{5}$$

$$IINF_t*civrif_{tl} = SEVPAY_l*done_{tl} \quad \forall\, t \le 6,\ l, \tag{6}$$

$$\sum_{t=1}^{6} done_{tl} = 1 \quad \forall\, l, \tag{7}$$

$$\sum_{t=1}^{6} envir_{tl} \geq ENVCOST_l \quad \forall\ l, \tag{8}$$

$$FIXLOW_{tl} \leq done_{tl} \leq FIXHIGH_{tl} \quad \forall\ t,\ l, \tag{9}$$

$$\begin{aligned} &pper_{tl} \leq 1\,\forall\, t,l; \quad done_{tl} \in \{0,1\}\,\forall t,l; \quad build_{tg} \in \{0,1\}\,\forall t,g; \quad civmove_{tl\mathrm{g}} \geq 0\forall t,l,g; \\ &milmove_{tl\mathrm{g}} \geq 0\forall t,l,g; \quad ship_{tl\mathrm{g}} \geq 0\forall t,l,g; \quad civrif_{tl} \geq 0\forall t,l; \quad uniql_{tl} \geq 0\forall t,l; \\ &uniqg_{tg} \geq 0\forall t,g; \quad envir_{tl} \geq 0\forall t,l; \quad hire_{tg} \geq 0\forall t,g; \quad dev_t \geq 0\forall t. \end{aligned} \tag{10}$$

6. Model Features

The objective function expresses the discounted total cost savings achieved over a 20-year period accounting for one-time costs, one-time cost savings, and the annual recurrent cost savings produced by BRAC actions. The first line of the objective is a constant to make BRACAS consistent with COBRA. The objective function value is in net present dollars when $dev_t = 0$ for all *t*.

Constraint (1) seeks to keep yearly expenditures within budget. The elastic variable dev_t allows its budget constraint to be violated at a per-unit penalty of $DEVPEN_t$.

Constraints (2a) and (2b) credits recurrent savings at the losing installation only after a sufficient number of personnel have moved.

Constraint (3) links personnel movement to prerequisites. Constraints (3a), (3b), and (3c) ensure the cumulative percentage of support personnel hired and equipment shipped to an installation is at least as great as the cumulative percentage of personnel moved. Constraint (3d) ensures the cumulative percentage of personnel moved to an installation does not exceed the amount allowed prior to completion of construction. This constraint accounts for the lag between construction start and completion.

Constraints (4a), (4b), (4c), and (4d) ensure a BRAC action is not completed until all actions generating one-time costs are completed.

Constraint (5) ensures minimum and maximum annual environmental cleanup funding.

Constraint (6) ensures all civilians reduction-in-force actions occur in the last year of the transition period for each BRAC action.

Constraint (7) ensures all actions from the losing installation occur by the sixth year.

Constraint (8) ensures a minimum six-year environmental cleanup funding for each losing installations by the sixth year.

Constraint (9) forces specific closures in specific years.

Constraint set (10) specifies variables as binary or continuous.

When Compares to prior versions of BRACAS, constraints (2a), (4b), (5), (8), and (9) are new and constraints (1), (2a), (3c), (4a), and (10) as well as the objective function have been modified.

IV. MODEL IMPLEMENTATION AND SAMPLE RESULTS

This chapter demonstrates the updated BRACAS by using the recommended installations and costs initially available for the U.S. Army's BRAC 1995 round. The data is for 112 major and minor installations (43 losing, 64 gaining, and 5 minor installations). Several scenarios are investigated. These include finding the annual budgets that provide the maximum NPV, and the impact on cost savings when the budget changes.

A. INITIAL INPUT DATA

All non-environmental cost data were extracted from COBRA [Dell 2004]. Consistent with prior BRACAS implementations (e.g., Dell [1998]), we use a zero percent inflation rate $(INF_t = 1 \quad \forall t)$ and a three percent discount rate (Table 2).

	YEAR					
	1996	**1997**	**1998**	**1999**	**2000**	**2001**
Discount Rate	**0.9853**	**0.9566**	**0.9288**	**0.9017**	**0.8755**	**0.8500**

Table 2. The Annual Discount Rate.

Table 3 shows the total procurement and construction costs avoided at losing installation (CON-S), and yearly cost savings after completing actions at all losing installations (REC-S).

	CONSTRUCTION SAVINGS	**RECURRING SAVINGS**
SAVINGS ($M)	**6.38**	**728.52**

Table 3. The Construction and Recurring Savings.

Table 4 shows the total cost of the HAP/RSE environment one-time cost for the losing and gaining installations (OTHER-C), the overhead and program planning support cost for the losing installations (PROG-C), the mothball shutdown cost for the losing installations (SHUT-C), the civilian RIF early retirement unemployment for the losing installations (PERS-C) and the civilian new hire for the gaining installations (PERS-C), and the total cost for the new military construction (including the family housing, information management, and land) for the losing and gaining installations (CON-C).

	OTHER	PROGRAM	SHUT DOWN	PERSONNEL	CONSTRUCTION
COSTS ($M)	44.94	43.51	72.46	30.14	603.94

Table 4. Cost Summary. Cost of HAP/RSE Environment One-Time Cost (OTHER-C), the Overhead and Program Planning Support Cost (PROG-C), Mothball Shutdown Cost (SHUT-C), the Civilian RIF Early Retirement Unemployment (PERS-C), the Civilian New Hire (PERS-C), and the Total Cost for the New Military Construction (CON-C).

Table 5 shows the total cost to move all military personnel (MIL-C), the total cost to move all civilians (CIV-C), the total cost to pack and ship all equipment (FRT-M), and the environmental cleanup cost (ENV-C).

	MILITARY MOVE	CIVILIAN MOVE	FREIGHT MOVE	ENVIRONMENTAL CLEANUP
COSTS ($M)	24.825	208.452	27.733	1018.609

Table 5. Moving and Environmental Cost Summary.

Table 6 shows the minimum and maximum fraction of environmental cleanup cost to be spent at each losing installations per year (1996-2001). These fractions reflect the historic percentages spent [Olwell 2004].

	YEARS					
	1996	1997	1998	1999	2000	2001
Low	13.4	11.6	19.6	23.0	8.2	15.1
High	14.8	12.7	21.6	25.2	9.1	16.6

Table 6. Annual Minimum and Maximum Percentage of Total Environmental Cleanup Funding Required at Each Losing Installation Each Year.

B. BRACAS IMPLEMENTATION

The General Algebraic Modeling System (GAMS) Version 13.99 [GAMS 2004] generates BRACAS, and solves it using XA [Sunset Software Technology 2004]. A personal desktop computer with 1.05 Gigahertz of random access memory and a 2.00 Gigahertz Intel Pentium processor is used. The test results for all scenarios generate approximately 3,600 variables, 900 binary variables, and 2,500 constraints. It takes fewer than five minutes to generate and solve each BRACAS instance with a solution guaranteed to be within 0.01 percent of optimal.

C. BRACAS SCENARIOS

1. Total Fund Scenario (Unconstrained Budget Scenario)

This scenario finds the best annual funding for all activities and all installations to achieve the maximum NPV. Without any budget limits, all installations can be closed in the first year except when construction lead-time restricts it at gaining installations.

Table 7 shows the resulting yearly (1996-2001) budget amounts.

	BUDGET YEARS					
	1996	1997	1998	1999	2000	2001
BUDGET ($M)	430	295	567	324	210	149

Table 7. Yearly (1996-2001) Budget that Maximize NPV.

Table 8 shows the resulting NPV.

TOTAL COST SAVINGS (NPV) ($M)	6,346
Elastic Variable Total ($M)	0

Table 8. The Result of the Maximum NPV of the Total Cost Savings.

2. Constrained Budget Scenarios

We consider several scenarios when the six years budget varies (Table 12). The first scenario is the annual budget BRACAS finds for the maximum NPV. The second scenario distributes the total requirement evenly. The other scenarios fix the first three years to levels found in [Dell 1998] and change the last three years.

Scenario	1996 Budget	1997 Budget	1998 Budget	1999 Budget	2000 Budget	2001 Budget
1	430	295	567	324	210	149
2	329	329	329	329	329	329
3	182	335	213	502	502	502
4	182	335	353	502	502	502
5	182	335	353	456	456	456

Table 9. The Yearly (1996-2001) Budget Allowed in Different Scenarios.

Table 10 shows the resulting 20-year NPV of the total cost savings and the elastic variable total.

Scenario	Total Cost Savings (NPV) ($M)	Elastic Variable Total ($M)
1	6,346	0.00
2	5,374	7.36
3	5889	155.45
4	5,929	16
5	5,850	16

Table 10. The 20-year NPV and the Elastic Variable Total in Different Scenarios.

BRACAS reschedules the BRAC actions to retain the maximum total cost savings 20-year NPV as the budget changes. The elastic variable total shows the additional funds required to achieve BRAC actions. The environmental cleanup cost requires a substantial portion of the budget in 1998 and most of these needed budget deviations occur in 1998. The above table indicates that the total cost savings NPV of the scenario decreases as the yearly (1996-2001) budget amounts for each execution are reduced.

For the first scenario, the majority of the actions from the losing installations occurred during the first three years, and for the remaining scenarios, nearly all the actions from the losing installations occurred during the last two or three years.

We consider a revised scenario 2 where we eliminate the environmental cleanup cost from the objective function. This has minimal impact on the solution but does increase the 20-year NPV by \$ 816 million. An independent revision to scenario 2 reduces the required lower limit of annual environmental cleanup funding (Table 6 row 4) by 10%, resulting in an increase of \$ 516 million to the 20-year NPV.

THIS PAGE INTENTIONALLY LEFT BLANK

V. CONCLUSIONS

This thesis updates an integer linear program BRACAS (Base Realignment and Closure Action Schedule). Its main contribution is a more realistic inclusion of environmental cleanup costs.

The United State Army used BRACAS to help guide the implementation of the 1995 round's actions. BRACAS schedules closure and realignment actions, and maximizes the net present value (NPV) of total cost savings while adhering to annual budget and other constraints. BRACAS suggests timetables for BRAC actions that both satisfy yearly budget constraints and maximize NPV. Prior BRACAS implementations simply fixed the environmental cleanup costs each year, or equivalently, just reduced the available yearly budget.

This thesis refines how environmental cleanup costs are modeled. It constrains yearly expenditures to be within a budget band (yearly lower and upper limits), adds a constraint to ensure a user-defined minimum total environmental funding over six years, adds a constraint that ensures minimum environmental funding before an installation is considered closed, and allows the environmental cleanup cost to be considered as part of the NPV calculation. We illustrated the revised BRACAS using seven scenarios from BRAC 1995. Letting BRACAS pick its yearly (1996-2001) budget, BRACAS finds a 20-year NPV of $6,346 million. We examine how closures and the 20-year NPV are changed for several scenarios where we restrict yearly budgets and alter the inclusion of environmental cleanup costs.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Ardic, S., 2001, "Funding Site Cleanup at Closing Army Installations: A Stochastic Optimization Approach," Master's Thesis, Naval Postgraduate School, Monterey, California.

Brown, G. G., Dell, R. F., and Wood, R. K., 1997, "Optimization and Persistence," *Interfaces*, Vol. 27, No. 5, pp.15-37.

Defense Technical Information Center, Environmental Web Site, http://www.dtic.mil/envirodod/Policies/PDBRAC.htm, Accessed on May 2004.

Dell, R. F. and Tarantino, W., 2003 "How Optimization Supports Army Base Closure and Realignment," Project Report, NPS-OR-03-003-PR, Naval Postgraduate School, Monterey, California.

Dell, R. F., 1998, "Optimizing Army Base Realignment and Closure," *Interfaces*, Vol. 27, No. 5, pp. 1-18.

Dell, R. F., 2004, Personal Communication with Associate Professor Robert Dell, Naval Postgraduate School, Monterey, California.

Free, E. J., 1994, "An Optimization Model for Scheduling Army Base Realignment and Closure Actions," Master's Thesis, Naval Postgraduate School, Monterey, California.

GAMS Development Corporation, 2004, "GAMS: A User's Guide," Washington, D.C.

Meagher, M. F., 2004, "A Low-Resolution Cost Model for Environmental Restoration of Closing Army Installations," Master's Thesis, Naval Postgraduate School, Monterey, California.

Olwell, D.H., 2004, Personal Communication with Senior Lecturer David H. Olwell, Naval Postgraduate School, Monterey, California.

Oremis, S., 2000, "Funding Site Cleanup at Closing Army Installations: An Integer Linear Programming Approach," Master's Thesis, Naval Postgraduate School, Monterey, California.

Sunset Software Technology 2004, "XA Solver," http://www.sunsetsoft.com, Accessed on May 2004.

United States Army Base Realignment and Closure Office Web Site, 2004, http://www.hqda.army.mil/acsimweb/brac/braco.htm, Accessed on May 2004.

United States General Accounting Office, 1996, "Military Base Closures: Reducing High Cost of Environmental Cleanup Requires Difficult Choices," United States General Accounting Office, GAO/NSIAD-96-172.

United States General Accounting Office, 1997, "Military Bases: Lessons Learned From Prior Base Closure Rounds," United States General Accounting Office, GAO/NSIAD-97-151.

Wong, C. G., 1995, "Base Realignment and Closure Action Scheduler (BRACAS)," Master's Thesis, Naval Postgraduate School, Monterey, California.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Professor Robert F. Dell
   Operations Research Department (Code OR/DE)
   Naval Postgraduate School
   Monterey, California

4. Professor David Olwell
   Operations Research Department (Code OR/OL)
   Naval Postgraduate School
   Monterey, California

5. Brigadier Abdul-Latif Rashid Al-Zayani
   BDF Assistant Chief of Staff for Operations
   Kingdom of Bahrain

6. COL William Tarantino
   Total Army Basing Study (TABS)
   Washington D.C.